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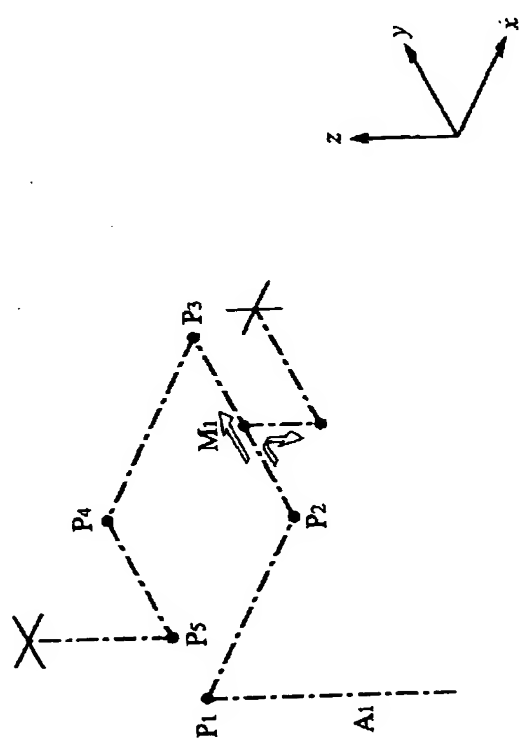
(54)【発明の名称】 立体視顕微鏡の撮影光学系

(57)【要約】

【課題】 合成焦点距離の長いスチルカメラ用撮影光学系を備えているにもかかわらず、不自然な突出を防止したコンパクトな立体視顕微鏡の撮影光学系を提供する。

【解決手段】 本発明の撮影光学系では、まず、立体視顕微鏡の観察光学系から導かれた光束A_1が、第１の反射部材P_1によって光束A_1に対して垂直方向に反射される。その後、順に、第２の反射部材P_2によってｙ方向に、第３の反射部材P_3によって－ｘ方向に、第４の反射部材P_4によって－ｙ方向に、第５の反射部材P_5によってｚ方向に反射されるようになっている。前記各反射部材P_1，P_2，P_3，P_4，P_5は全て入射光軸（ｚ軸）を法線とするｘｙ平面上に配置されている。



【特許請求の範囲】

【請求項１】　立体視顕微鏡の撮影光学系であって、該撮影光学系への入射光軸を法線とする平面を基準に±２０°の平面内に前記入射光軸を屈折させるための反射部材が配置されていることを特徴とする撮影光学系。

【請求項２】　立体視顕微鏡の観察光学系の光路から光路分割器で分岐された光路上に配置され、光路切換え部材，スチルカメラ用光学系及びＴＶカメラ用光学系を備え、前記観察光学系からの光路を前記光路切換え部材によって前記スチルカメラ用光学系又はＴＶカメラ用光学系へ切換えて導くことが可能な立体視顕微鏡の撮影光学系において、

前記スチルカメラ用光学系又はＴＶカメラ用光学系の少なくとも一方の光路は、前記撮影光学系への入射光軸を法線とする平面を基準に±２０°の平面内に少なくとも３つの反射部材を有し、該平面内に前記光路切換え部材が配置されていることを特徴とする撮影光学系。

【請求項３】　立体視顕微鏡の観察光学系の光路から光路分割器で分岐された光路上に配置された立体視顕微鏡の撮影光学系において、

前記観察光学系からの光束を結像させる結像レンズ，光路切換え部材，スチルカメラに結像させるリレー光学系，及びＴＶカメラに結像させるリレー光学系を備え、前記スチルカメラに結像させるリレー光学系の結像倍率を１乃至７倍にしたことを特徴とする撮影光学系。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は立体視顕微鏡で捕らえた像を撮影するための撮影光学系に関する。

【０００２】

【従来の技術】現在、顕微鏡観察では、観察視野を記録する目的等で、スチルカメラによる静止画像の記録や、ＴＶカメラ撮影によるモニターでの拡大観察、動画の記録が行われている。なかでも、立体視顕微鏡、特に手術用顕微鏡においては、マイクロサージャリー技術の進展，普及に伴い、手技の教育又は重要な症例の記録のために、ＴＶカメラやスチルカメラにより術視野を顕微鏡を通した拡大画像で撮影しておく必要がある。このため、顕微鏡の観察光路に光路分割器を設けて、これにより分割された光路上にＴＶカメラやスチルカメラの撮影装置の取付けが可能になっている。手技の進行記録のためにはＴＶカメラ、症例の鮮明な記録のためにはスチルカメラによる撮影が好ましい。従って、手術用顕微鏡にはその両方が取付け可能になっていることが望ましい。

【０００３】このような要望を満足するものとしては、特許第２５９６９２６号の撮影装置がある。図８はこの撮影装置の構成を示す光軸に沿う断面図である。この撮影装置２１は顕微鏡２２の観察光学系から分岐された光路上に配置されて用いられる。撮影装置２１は、顕微鏡２２の観察光学系からの光束を結像させる結像レンズ２３，入射光を２回反射して入射光軸と１３５°をなす方向に出射するプリズム２４，光路切換えミラー２５，ＴＶカメラ用リレー光学系２６，及び写真撮影用リレー光学系２７により構成されている。この撮影装置２１は、光路切換えミラー２５により光束をＴＶカメラ用リレー光学系２６に導きＴＶカメラの撮像素子面に結像させることができる一方、光路切換えミラー２５により光束を写真用リレー光学系２７に導きカメラの写真フィルム面に結像させることもできる。

【０００４】

【発明が解決しようとする課題】しかしながら、立体視顕微鏡にスチルカメラを用いる場合、撮像範囲を観察系と同等にするには、撮影光学系の合成焦点距離を長く形成して拡大像を得る必要がある。例えば、対物レンズと変倍レンズが顕微鏡像の観察系と撮影系とで共通に使用されており、観察系の結像レンズの焦点距離BI_ｆ が168mm 、視野数FNが20、スチルカメラの像高h が21.6mmであった場合、スチルカメラ用撮影光学系に必要とされる合成焦点距離は、

$$(h \times 2/FN) \times BI\_f = (21.6\times 2/20) \times 168 = 362.88 (mm)$$

となる。

【０００５】これはあくまで一例であるが、スチルカメラ用撮影光学系の撮像範囲を観察系と同等にするには、その撮影光学系の合成焦点距離は300mm 程度、場合によってはそれ以上必要となる。この合成焦点距離をもつ撮影光学系の全長は長くなり、よって、かかる撮影光学系をそのまま顕微鏡に取付けると、例えば図８に示されているものの場合、L_1 方向に突出してしまい、術者にとって使い勝手の悪いものとなる。

【０００６】又、手術用顕微鏡においては、より難しい手術を可能にするため、複数人が同一の顕微鏡像を同時に自由な方向から観察できることが望まれる。この要求に応じるため、術者が左右の目で見る夫々の像を１つの変倍光学系を通して観察できるようにした観察光学系が提案されている。この構成を図９に示す。この観察光学系は、光軸が１つの対物レンズ２９，変倍光学系３１，リレーレンズ３３，３７，左右一対の結像レンズ３８ｌ，３８ｒ，接眼レンズ３９ｌ，３９ｒを有し、アイポイント位置の調節のために前記各光学部材の間に夫々反射面２８，３０，３２，３４，３５，３６が配置されている。

【０００７】このように構成された観察光学系に撮影光学系を取付ける場合、反射面３２に代えて光路分割器を取付け、顕微鏡からの光路を観察光学系用と撮影光学系用とに分岐することが考えられる。この場合、撮影光学系が図中L_2 方向に突出してしまうことになる。これでは、鏡体とこの鏡体を吊り下げるアームとの重量バランスが崩れてしまううえ、前記撮影光学系の操作性，コンパクト性も損なわれてしまうことになる。

【０００８】そこで、本発明は上記問題点に鑑み、合成焦点距離の長いスチルカメラ用撮影光学系を備えているにもかかわらず、不自然な突出を防止してコンパクトな立体視顕微鏡の撮影光学系を提供することを目的とする。

【０００９】

【課題を解決するための手段】上記目的を達成するために、本発明は、立体視顕微鏡の撮影光学系であって、該撮影光学系への入射光軸を法線とする平面を基準に±２０°の平面内に前記入射光軸を屈折させるための反射部材が配置されていることを特徴とする。

【００１０】又、本発明は、立体視顕微鏡の観察光学系の光路から光路分割器で分岐された光路上に配置され、光路切換え部材，スチルカメラ用光学系及びＴＶカメラ用光学系を備え、前記観察光学系からの光路を前記光路切換え部材によって前記スチルカメラ用光学系又はＴＶカメラ用光学系へ切換えて導くことが可能な立体視顕微鏡の撮影光学系において、前記スチルカメラ用光学系又はＴＶカメラ用光学系の少なくとも一方の光路は、前記撮影光学系への入射光軸を法線とする平面を基準に±２０°の平面内に少なくとも３つの反射部材を有し、その平面内に前記光路切換え部材が備えられていることを特徴とする。

【００１１】更に、本発明は、立体視顕微鏡の観察光学系の光路から光路分割器で分岐された光路上に配置された立体視顕微鏡の撮影光学系において、前記観察光学系からの光束を結像させる結像レンズ，光路切換え部材，スチルカメラに結像させるリレー光学系，及びＴＶカメラに結像させるリレー光学系を備え、特に前記スチルカメラに結像させるリレー光学系の結像倍率を１乃至７倍にしたことを特徴とする。

【００１２】

【発明の実施の形態】図１は本発明の立体視顕微鏡の撮影光学系の基本構成を示す概念図である。本発明の撮影光学系では、まず、図示しない立体視顕微鏡の観察光学系から導かれた光束A_1が、第１の反射部材P_1によって光束A_1に対して垂直方向（図中のｘ方向）に反射される。その後、順に、第２の反射部材P_2によってｙ方向に、第３の反射部材P_3によって－ｘ方向に、第４の反射部材P_4によって－ｙ方向に、第５の反射部材P_5によってｚ方向に反射されるようになっている。前記各反射部材P_1，P_2，P_3，P_4，P_5は全て入射光軸（ｚ軸）を法線とするｘｙ平面上に配置されている。このように、第１の反射部材P_1から第５の反射部材P_5までの光路をｘｙ平面上に形成することにより、撮影光学系のｚ方向への突出を抑制している。

【００１３】又、本発明の撮影光学系では、前記ｘｙ平面上で、第２の反射部材P_2と第３の反射部材P_3との間に光路切換え部材M_1が配置されている。そして、この光路切換え部材M_1により、スチルカメラ用光路とＴＶカメラ用光路とに切換えることができる。このようにして、スチルカメラ，ＴＶカメラ用の光路を有する撮影光学系でありながらも、コンパクトな撮影光学系を達成している。

【００１４】又、反射部材P_1で入射光束A_1をｘ方向ばかりでなく、－ｘ方向や±ｙ方向へ折り曲げることも可能である。本発明の撮影光学系では、ｘｙ平面内或いはｘｙ平面に対して±２０°以内の平面内であれば、入射光束A_1をどの方向に反射させる構成をとってもｚ方向への突出を抑えることができる。又、撮影光学系のメカ的な都合上、又は像を回転させることにより、図２，３に示すように、反射部材P_4，P_5又は反射部材P_5のみを省略しても前記と同様に撮影光学系の図のｚ方向への突出を抑制することができる。更に、図示されているように、光路切換え部材M_1の配置位置を変えてもよい。又、光路切換え部材M_1は軽量であることが望ましく、この点ミラーが好適である。

【００１５】又、本発明の撮影光学系は、前述の各光学部材の他、立体視顕微鏡の観察光学系から導かれる光束を結像させる結像レンズ，スチルカメラに結像させるリレー光学系，及びＴＶカメラに結像させるリレー光学系を備えている。特に、前記スチルカメラに結像させるリレー光学系の結像倍率βｒは１乃至７倍に設定される。

【００１６】ここで、前記スチルカメラに結像させるリレー光学系の結像倍率βｒが７倍を越えると、かかるリレー光学系の補正係数が大きくなり、リレー光学系を精度よく組立てることが必要となるため、撮影光学系全体で組立工程の作業性が劣化する。又、収差補正も困難になる。一方、かかるリレー光学系の結像倍率βｒが１倍を下回ると、撮影光学系の中間結像点付近の光束径が大きくなり、リレー光学系のコンパクト化の妨げとなる。又、補正係数が小さくなり、そのリレー光学系を移動させることによって光軸調整を行うと、調整量が大きすぎてやはりコンパクト化の妨げになる。尚、前記スチルカメラに結像させるリレー光学系の結像倍率βｒは３乃至５倍の範囲に設定することが好ましく、３．７倍が最適である。

【００１７】又、本発明の撮影光学系では、立体視顕微鏡の観察光学系から導かれる光束を結像させる結像レンズにより形成される中間像の位置に更なるレンズを配置することによって、中間結像位置以後の光束径を十分小さくでき、光学系全体のコンパクト化が図れる。しかも、光学性能を劣化させることもない。ここで、本発明の撮影光学系において、立体視顕微鏡の観察光学系からの光束を結像させる結像レンズのＦナンバーをF_{no_k}、前記結像レンズにより形成される中間像位置に配置されるレンズの厚みをt、としたとき、次の条件式を満足することが好ましい。

$$0.3 < F_{no\_k}/t < 7.5 \quad \cdots\cdots (1)$$

【0018】Fno ₋k/t の値が条件式（1）の取り得る値の範囲の上限を越えると、前記中間像位置に配置されるレンズの肉厚が薄くなり中間像とレンズ面とが重なるので、このレンズに付着するゴミ，キズがスチルカメラ，ＴＶカメラの像に取り込まれてしまい、良好な像が得られないという不具合が発生する。一方、Fno ₋k/t の値が条件式（1）の取り得る値の範囲の下限を下回ると、撮影光学系の光学性能が悪化する。特に、前記中間像位置に配置されるレンズの肉厚が厚い場合、中間像とレンズ面とが離れすぎて歪曲収差（ディストーション）が悪化し、好ましくない。

【0019】又、前記スチルカメラに結像させるリレー光学系は、物体側から順に、正の焦点距離を有する第１レンズ群と負の焦点距離を有する第２レンズ群とからなる２群構成となっている。加えて、第１レンズ群が凸レンズ、第２レンズ群が凹レンズで構成されるテレホトタイプを採用すれば、リレー光学系の全長を短縮できる。又、色収差の補正をしつつ、リレー光学系のコンパクト化を図るためには、第２レンズ群の凹レンズに接合レンズを用いると有効である。更に、前記各レンズ群中に少なくとも１つの接合レンズが含まれていることが好ましい。このように構成することによって、夫々のレンズ群で発生する色収差を良好に補正することができる。

【0020】本発明の撮影光学系では、入射瞳位置を第１レンズ群付近に設定することによって、第１レンズ群の接合レンズで軸上の色収差を、第２レンズ群で倍率の色収差を夫々補正することができ、撮影光学系の全長も短縮しつつ良好な光学性能を得ることができる。

【0021】以下、図示した実施例に基づき本発明を詳細に説明する。

【0022】第１実施例

図４は本実施例にかかる立体視顕微鏡の撮影光学系の構成を示す図である。又、図５は図４に示された撮影光学系の光軸に沿う断面図である。本実施例の撮影光学系は、図示しない立体視顕微鏡の観察光学系側から順に、結像レンズk_{11}，２回反射のプリズムP_{11}，直角プリズムp_{12}，結像レンズk_{11}で得られる中間像位置に配置されたレンズ（瞳リレーレンズ）h_{11}，光路切換えミラーm_{11}，直角プリズムp_{13}，スチルカメラ用リレー光学系s_{11}，及び直角プリズムp_{14}が夫々配置されている。又、光路切換えミラーm_{11}により分岐された光軸上には、順に、直角プリズムp_{15}，ＴＶカメラ用リレー光学系t_{11}が配置されている。

【0023】ここで、スチルカメラ用リレー光学系s_{11}は、直角プリズムp_{13}側から順に、明るさ絞り１，正レンズ２，正レンズ３，負レンズ４，正レンズと負レンズとからなる接合レンズ５が配置されて構成されている。一方、ＴＶカメラ用リレー光学系t_{11}は、直角プリズムP_{15}側から順に、正レンズ６，明るさ絞り７，正レンズ８，負レンズ９，負レンズと正レンズとからなる接合レンズ１０が配置されて構成されている。

【0024】本実施例の撮影光学系は、まず、前記観察光学系から導かれた光束を、結像レンズk_{11}を透過させることにより中間像を形成し、これを２回反射プリズムp_{11}にて入射光軸を法線とする平面に沿う方向へ垂直に反射させる。次に、その像は、直角プリズムp_{12}で反射され、瞳リレーレンズh_{11}でこの後の光束径を細くした後に、後述するように、スチルカメラ用リレー光学系s_{11}又はＴＶカメラ用リレー光学系t_{11}へ導かれる。

【0025】写真撮影時には、光路切換えミラーm_{11}を図中の点線位置に移動させる。これにより、瞳リレーレンズh_{11}を経た顕微鏡像は、直角プリズムp_{13}，スチルカメラ用リレー光学系s_{11}を順に透過し、直角プリズムp_{14}にてスチルカメラ（不図示）へ導かれる。一方、ＴＶ撮影時には、光路切換えミラーm_{11}を図中の実線位置に移動させる。瞳リレーレンズh_{11}を経た顕微鏡像は、光路切換えミラーm_{11}により反射されて直角プリズムp_{15}へと導かれる。更に、直角プリズムp_{15}で反射された像は、ＴＶカメラ用リレー光学系t_{11}を介してＴＶカメラ（不図示）へ導かれる。

【0026】このように、本実施例では、撮影光学系の焦点距離は長くなるが、光路を撮影光学系への入射光軸を法線とする平面に沿う方向に形成することにより、撮影光学系の前記入射光軸に沿う方向への突出を防ぐことができ、コンパクトな撮影光学系を達成している。

【0027】又、本実施例では、スチルカメラ用リレー光学系s_{11}の倍率βrを４．８倍とすることで、補正係数も小さくなり、収差補正も良好になる。

【0028】更に、本実施例の撮影光学系において、立体視顕微鏡の観察光学系からの光束を結像させる結像レンズk_{11}のＦナンバーをFno ₋k 、結像レンズk_{11}で得られる中間像位置に配置された瞳リレーレンズh_{11}の厚みをt としたとき、Fno ₋k/t ＝0.86である。これにより、瞳リレーレンズh_{11}に付着するゴミ，キズがスチルカメラ，ＴＶカメラの像に取り込まれてしまうことがなく、収差も良好に補正できる。

【0029】以下、本実施例の撮影光学系を構成する各光学部材の数値データを示す。

【0030】（スチルカメラ撮影時）

$R_1 = 74.8010$

$D_1 = 5.8000$　　$n_1 = 1.72916$　　$\nu_1 = 54.68$

$R_2 = -37.9660$

$D_2 = 2.5000$　　$n_2 = 1.80100$　　$\nu_2 = 34.97$

$R_3 = -202.1440$

$D_3 = 21.7000$

$R_4 = \infty$

$D_4 = 10.0000$　　$n_4 = 1.56883$　　$\nu_4 = 56.33$

$R_5 = \infty$

$D_5 = 10.0000$　　$n_5 = 1.56883$　　$\nu_5 = 56.33$

【0031】

$R_6=\infty$
$D_6=0$
$R_7=\infty$
$D_7=9.5000$　$n_7=1.56883$　$\nu_7=56.33$
$R_8=\infty$
$D_8=9.5000$　$n_8=1.56883$　$\nu_8=56.33$
$R_9=\infty$
$D_9=24.0000$
$R_{10}=\infty$
$D_{10}=6.0000$　$n_{10}=1.56883$　$\nu_{10}=56.33$

【0032】

$R_{11}=\infty$
$D_{11}=6.0000$　$n_{11}=1.56883$　$\nu_{11}=56.33$
$R_{12}=\infty$
$D_{12}=0.5000$
$R_{13}=80.0080$
$D_{13}=9.0000$　$n_{13}=1.51633$　$\nu_{13}=64.15$
$R_{14}=-80.0080$
$D_{14}=31.5000$
$R_{15}=\infty$
$D_{15}=6.0000$　$n_{15}=1.56883$　$\nu_{15}=56.33$

【0033】

$R_{16}=\infty$
$D_{16}=6.0000$　$n_{16}=1.56883$　$\nu_{16}=56.33$
$R_{17}=\infty$
$D_{17}=4.6590$
$R_{18}=\infty$
$D_{18}=0$
$R_{19}=34.7920$
$D_{19}=1.6700$　$n_{19}=1.51633$　$\nu_{19}=64.15$
$R_{20}=-22.7570$
$D_{20}=0.1000$

【0034】

$R_{21}=8.0580$
$D_{21}=2.4000$　$n_{21}=1.51633$　$\nu_{21}=64.15$
$R_{22}=\infty$
$D_{22}=2.6500$
$R_{23}=-20.6720$
$D_{23}=3.1800$　$n_{23}=1.76182$　$\nu_{23}=26.52$
$R_{24}=7.3790$
$D_{24}=4.3700$
$R_{25}=15.3450$
$D_{25}=2.0000$　$n_{25}=1.72151$　$\nu_{25}=29.24$

【0035】

$R_{26}=-29.1410$
$D_{26}=1.9300$　$n_{26}=1.58913$　$\nu_{26}=61.18$
$R_{27}=12.9180$
$D_{27}=14.5260$
$R_{28}=\infty$
$D_{28}=17.0000$　$n_{28}=1.74330$　$\nu_{28}=49.22$
$R_{29}=\infty$
$D_{29}=89.7579$
$R_{30}=\infty$

【0036】（TVカメラ撮影時）

$r_1=74.8010$
$d_1=5.8000$　$n_1=1.72916$　$\nu_1=54.68$
$r_2=-37.9660$
$d_2=2.5000$　$n_2=1.80100$　$\nu_2=34.97$
$r_3=-202.1440$
$d_3=21.7000$
$r_4=\infty$
$d_4=10.0000$　$n_4=1.56883$　$\nu_4=56.33$
$r_5=\infty$
$d_5=10.0000$　$n_5=1.56883$　$\nu_5=56.33$

【0037】

$r_6=\infty$
$d_6=9.5000$　$n_6=1.56883$　$\nu_6=56.33$
$r_7=\infty$
$d_7=9.5000$　$n_7=1.56883$　$\nu_7=56.33$
$r_8=\infty$
$d_8=24.0000$
$r_9=\infty$
$d_9=6.0000$　$n_9=1.56883$　$\nu_9=56.33$
$r_{10}=\infty$
$d_{10}=6.0000$　$n_{10}=1.56883$　$\nu_{10}=56.33$

【0038】

$r_{11}=\infty$
$d_{11}=0.5000$
$r_{12}=80.0080$
$d_{12}=9.0000$　$n_{12}=1.51633$　$\nu_{12}=64.15$
$r_{13}=-80.0080$
$d_{13}=16.5000$
$r_{14}=\infty$
$d_{14}=10.2000$
$r_{15}=\infty$
$d_{15}=6.0000$　$n_{15}=1.56883$　$\nu_{15}=56.33$

【0039】

$r_{16}=\infty$
$d_{16}=6.0000$　$n_{16}=1.56883$　$\nu_{16}=56.33$
$r_{17}=\infty$
$d_{17}=3.0000$
$r_{18}=\infty$
$d_{18}=2.2000$　$n_{18}=1.51633$　$\nu_{18}=64.15$
$r_{19}=-38.2470$
$d_{19}=10.5000$
$r_{20}=\infty$
$d_{20}=6.6800$

【0040】

$r_{21}=10.2370$
$d_{21}=4.0000$　$n_{21}=1.69680$　$\nu_{21}=55.53$

r_{22}=82.7710
d_{22}=3.4100
r_{23}=-17.8940
d_{23}=3.3000　n_{23}=1.74077　ν_{23}=27.79
r_{24}=8.1750
d_{24}=4.2900
r_{25}=34.6150
d_{25}=1.5000　n_{25}=1.64769　ν_{25}=33.80

【００４１】
r_{26}=13.4990
d_{26}=4.0000　n_{26}=1.78590　ν_{26}=44.19
r_{27}=-18.4600
d_{27}=34.4310
r_{28}=∞

【００４２】第２実施例
図６は本実施例にかかる立体視顕微鏡の撮影光学系の構成を示す図である。又、図７は図６に示された撮影光学系の光軸に沿う断面図である。本実施例の撮影光学系は、図示しない立体視顕微鏡の観察光学系側から順に、明るさ絞り１１，結像レンズk_{21}，３回反射のプリズムP_{21}，ペンタプリズムp_{22}，結像レンズk_{21}で得られる中間像位置に配置されたレンズ（瞳リレーレンズ）h_{21}，光路切換えミラーm_{21}，ペンタプリズムp_{23}，スチルカメラ用リレー光学系s_{21}，及び直角プリズムp_{24}，P_{25}が夫々配置されている。又、光路切換えミラーm_{21}により分割された光軸上には、順に、直角プリズムp_{26}，ＴＶカメラ用リレー光学系t_{21}が配置されている。

【００４３】ここで、スチルカメラ用リレー光学系s_{21}は、ペンタプリズムp_{23}側から順に、正の屈折力を備えた第１レンズ群１２と、負の屈折力を備えた第２レンズ群１３とが配置されて構成されている。更に、第１レンズ群１２は、ペンタプリズムp_{23}側から順に、両凸レンズ１２ａ，正レンズと負レンズとからなる正の接合レンズ１２ｂが配置されて構成されている。又、第２レンズ群１３は、正レンズと負レンズとからなる負の接合レンズにより構成されている。一方、ＴＶカメラ用リレー光学系t_{21}は、直角プリズムP_{26}側から順に、明るさ絞り１４，正レンズ１５，負レンズ１６，負レンズと正レンズとからなる接合レンズ１７が配置されて構成されている。

【００４４】本実施例の撮影光学系は、まず、前記観察光学系から導かれた光束を、結像レンズk_{21}を透過させることにより中間像を形成し、これを３回反射プリズムp_{21}にて入射光軸を法線とする平面に沿う方向へ垂直に反射させる。次に、その像は、ペンタプリズムp_{22}で２回反射され、瞳リレーレンズh_{21}でこの後の光束径を細くした後に、後述するように、光路をスチルカメラ用リレー光学系s_{21}又はＴＶカメラ用リレー光学系t_{21}へ導かれる。

【００４５】写真撮影時には、光路切換えミラーm_{21}を図中の点線位置に移動させる。これにより、瞳リレーレンズh_{21}を経た顕微鏡像は、ペンタプリズムp_{23}，スチルカメラ用リレー光学系s_{21}を順に透過し、直角プリズムp_{24}，P_{25}を経てスチルカメラ（不図示）へ導かれる。一方、ＴＶ撮影時には、光路切換えミラーm_{21}を図中の実線位置に移動させる。瞳リレーレンズh_{21}を経た顕微鏡像は、光路切換えミラーm_{21}により反射されて直角プリズムp_{26}へと導かれる。更に、直角プリズムp_{26}で反射された像は、ＴＶカメラ用リレー光学系t_{21}を介してＴＶカメラ（不図示）へ導かれる。

【００４６】このように、本実施例では、第１実施例に示したものと同様、撮影光学系の焦点距離は長くなるが、光路を撮影光学系への入射光軸を法線とする平面に沿う方向に形成することにより、撮影光学系の前記入射光軸に沿う方向への突出を防ぐことができ、コンパクトな撮影光学系を達成している。

【００４７】又、本実施例では、スチルカメラ用リレー光学系s_{21}の倍率βrを３．７倍とすることで、第１実施例の撮影光学系よりも補正係数を小さくでき、より収差補正が良好になる。

【００４８】更に、本実施例の撮影光学系において、立体視顕微鏡の観察光学系からの光束を結像させる結像レンズk_{21}のＦナンバーをFno_{-k}、結像レンズk_{21}で得られる中間像位置に配置された瞳リレーレンズh_{21}の厚みをtとしたとき、
$Fno_{-k}/t=0.86$
である。これにより、瞳リレーレンズh_{11}に付着するゴミ，キズがスチルカメラ，ＴＶカメラの像に取り込まれてしまうことがなく、収差も良好に補正できる。

【００４９】以下、本実施例の撮影光学系を構成する各光学部材の数値データを示す。

【００５０】（スチルカメラ撮影時）
R_1=∞
D_1=3.0500
R_2=62.3180
D_2=3.0000　n_2=1.48749　ν_2=70.23
R_3=-53.3190
D_3=1.8000　n_3=1.72342　ν_3=37.95
R_4=-137.0720
D_4=3.0000
R_5=∞
D_5=8.0000　n_5=1.56883　ν_5=56.33

【００５１】
R_6=∞
D_6=8.0000　n_6=1.56883　ν_6=56.33
R_7=∞
D_7=8.0000　n_7=1.56883　ν_7=56.33
R_8=∞
D_8=16.0000　n_8=1.56883　ν_8=56.33

$R_9=\infty$
$D_9=8.0000$　$n_9=1.56883$　$\nu_9=56.33$
$R_{10}=\infty$
$D_{10}=44.0000$

【0052】
$R_{11}=\infty$
$D_{11}=16.9000$　$n_{11}=1.51633$　$\nu_{11}=64.15$
$R_{12}=\infty$
$D_{12}=14.0000$　$n_{12}=1.51633$　$\nu_{12}=64.15$
$R_{13}=\infty$
$D_{13}=16.9000$　$n_{13}=1.51633$　$\nu_{13}=64.15$
$R_{14}=\infty$
$D_{14}=2.0000$
$R_{15}=46.0390$
$D_{15}=9.0000$　$n_{15}=1.51633$　$\nu_{15}=64.15$

【0053】
$R_{16}=-46.0390$
$D_{16}=34.3000$
$R_{17}=\infty$
$D_{17}=13.2800$　$n_{17}=1.51633$　$\nu_{17}=64.15$
$R_{18}=\infty$
$D_{18}=11.0000$　$n_{18}=1.51633$　$\nu_{18}=64.15$
$R_{19}=\infty$
$D_{19}=13.2800$　$n_{19}=1.51633$　$\nu_{19}=64.15$
$R_{20}=\infty$
$D_{20}=9.0100$

【0054】
$R_{21}=36.5760$
$D_{21}=2.0000$　$n_{21}=1.51633$　$\nu_{21}=64.14$
$R_{22}=-36.5760$
$D_{22}=0.2000$
$R_{23}=16.9530$
$D_{23}=2.4000$　$n_{23}=1.51633$　$\nu_{23}=64.14$
$R_{24}=-30.2290$
$D_{24}=1.1000$　$n_{24}=1.76182$　$\nu_{24}=26.52$
$R_{25}=\infty$
$D_{25}=11.9000$

【0055】
$R_{26}=-58.4740$
$D_{26}=2.0000$　$n_{26}=1.78472$　$\nu_{26}=25.68$
$R_{27}=-19.8070$
$D_{27}=1.1000$　$n_{27}=1.72916$　$\nu_{27}=54.68$
$R_{28}=10.4010$
$D_{28}=8.1900$
$R_{29}=\infty$
$D_{29}=8.5000$　$n_{29}=1.73400$　$\nu_{29}=51.47$
$R_{30}=\infty$
$D_{30}=8.5000$　$n_{30}=1.73400$　$\nu_{30}=51.47$

【0056】
$R_{31}=\infty$
$D_{31}=4.0000$
$R_{32}=\infty$
$D_{32}=9.5000$　$n_{32}=1.73400$　$\nu_{32}=51.47$
$R_{33}=\infty$
$D_{33}=9.5000$　$n_{33}=1.73400$　$\nu_{33}=51.47$
$R_{34}=\infty$
$D_{34}=75.4978$
$R_{35}=\infty$

【0057】（TVカメラ撮影時）
$r_1=\infty$
$d_1=3.0500$
$r_2=62.3180$
$d_2=3.0000$　$n_2=1.48749$　$\nu_2=70.23$
$r_3=-53.3190$
$d_3=1.8000$　$n_3=1.72342$　$\nu_3=37.95$
$r_4=-137.0720$
$d_4=3.0000$
$r_5=\infty$
$d_5=8.0000$　$n_5=1.56883$　$\nu_5=56.33$

【0058】
$r_6=\infty$
$d_6=8.0000$　$n_6=1.56883$　$\nu_6=56.33$
$r_7=\infty$
$d_7=8.0000$　$n_7=1.56883$　$\nu_7=56.33$
$r_8=\infty$
$d_8=16.0000$　$n_8=1.56883$　$\nu_8=56.33$
$r_9=\infty$
$d_9=8.0000$　$n_9=1.56883$　$\nu_9=56.33$
$r_{10}=\infty$
$d_{10}=44.0000$

【0059】
$r_{11}=\infty$
$d_{11}=16.9000$　$n_{11}=1.51633$　$\nu_{11}=64.15$
$r_{12}=\infty$
$d_{12}=14.0000$　$n_{12}=1.51633$　$\nu_{12}=64.15$
$r_{13}=\infty$
$d_{13}=16.9000$　$n_{13}=1.51633$　$\nu_{13}=64.15$
$r_{14}=\infty$
$d_{14}=2.0000$
$r_{15}=46.0390$
$d_{15}=9.0000$　$n_{15}=1.51633$　$\nu_{15}=64.15$

【0060】
$r_{16}=-46.0390$
$d_{16}=16.5000$
$r_{17}=\infty$
$d_{17}=15.0000$
$r_{18}=\infty$
$d_{18}=6.0000$　$n_{18}=1.56883$　$\nu_{18}=56.36$
$r_{19}=\infty$
$d_{19}=6.0000$　$n_{19}=1.56883$　$\nu_{19}=56.36$

$r_{20}=\infty$
$d_{20}=15.2000$

【0061】

$r_{21}=\infty$
$d_{21}=8.0000$
$r_{22}=7.9020$
$d_{22}=2.8500$　$n_{22}=1.80610$　$\nu_{22}=40.92$
$r_{23}=52.0250$
$d_{23}=2.8000$
$r_{24}=-15.0020$
$d_{24}=2.5000$　$n_{24}=1.80518$　$\nu_{24}=25.42$
$r_{25}=5.6570$
$d_{25}=4.7000$

【0062】

$r_{26}=28.0680$
$d_{26}=1.3000$　$n_{26}=1.78472$　$\nu_{26}=25.68$
$r_{27}=10.2000$
$d_{27}=4.6000$　$n_{27}=1.78590$　$\nu_{27}=44.20$
$r_{28}=-13.2510$
$d_{28}=30.8540$
$r_{29}=\infty$

【0063】尚、前述した各実施例の数値データにおいて、R_1，r_1，・・・・は各レンズ面等の曲率半径、D_1，d_1，・・・・は各レンズ等の肉厚又はそれらの間隔、n_1，n_2，・・・・は各レンズ等の屈折率、ν_1，ν_2，・・・・は各レンズ等のアッベ数を示している。

【0064】ここで、第１実施例及び第２実施例に夫々示した撮影光学系では、２回反射プリズム，３回反射プリズム，ペンタプリズムを用いているが、スチルカメラ，ＴＶカメラを回転させることにより像の回転が可能であれば、前記各プリズムに代えて直角プリズムを用いてもよい。又、プリズムの代わりにミラーを用いることも可能である。尚、スチルカメラ，ＴＶカメラの位置を入れ換えてもよいことは云うまでもない。

【0065】以上説明したように、本発明による立体視顕微鏡の撮影光学系は、特許請求の範囲に記載された特徴と合わせ、以下の（１）～（３）に示すような特徴も備えている。

【0066】（１）前記立体視顕微鏡の観察光学系からの光束を結像させる結像レンズにより形成される中間像の位置にレンズが配置されていることを特徴とする請求項３に記載の立体視顕微鏡の撮影光学系。

【0067】（２）前記立体視顕微鏡の観察光学系からの光束を結像させる結像レンズのＦナンバーをFno_{k}、前記中間像位置に配置されたレンズの厚みをt としたとき、以下の条件式を満足するようにしたことを特徴とする前記（１）に記載の立体視顕微鏡の撮影光学系。

$0.3 < Fno_{k}/t < 7.5$

【0068】（３）前記スチルカメラに結像させるリレー光学系は、前記立体視顕微鏡の観察光学系側から順に、正の焦点距離を備えた第１レンズ群と負の焦点距離を備えた第２レンズ群とが配置されてなる２群構成であり、各々のレンズ群中には少なくとも１つの接合レンズが含まれていることを特徴とする前記（２）に記載の立体視顕微鏡の撮影光学系。

【0069】

【発明の効果】上述のように、本発明によれば、撮影光学系の焦点距離を長く形成しても、撮影光学系が不自然に突出することがなく、コンパクトな立体視顕微鏡の撮影光学系を提供することができる。

【図面の簡単な説明】

【図１】本発明による立体視顕微鏡の撮影光学系の構成を示す概念図である。

【図２】本発明による立体視顕微鏡の撮影光学系の他の構成を示す概念図である。

【図３】本発明による立体視顕微鏡の撮影光学系の他の構成を示す概念図である。

【図４】第１実施例にかかる立体視顕微鏡の撮影光学系の構成を示す図である。

【図５】図４に示した撮影光学系の光軸に沿う断面図である。

【図６】第２実施例にかかる立体視顕微鏡の撮影光学系の構成を示す図である。

【図７】図６に示した撮影光学系の光軸に沿う断面図である。

【図８】従来の顕微鏡の撮影装置の構成を示す光軸に沿う断面図である。

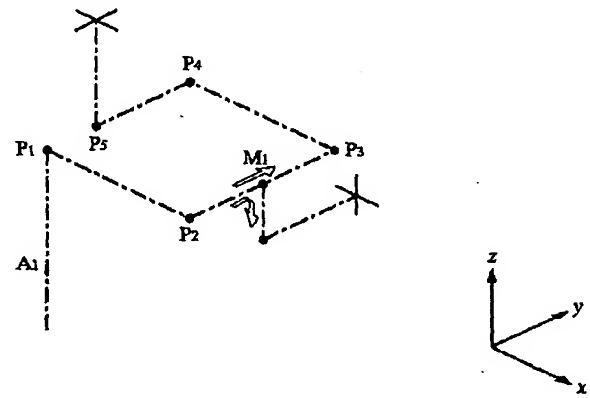
【図９】従来の顕微鏡の観察装置の構成を示す光軸に沿う断面図である。

【符号の説明】

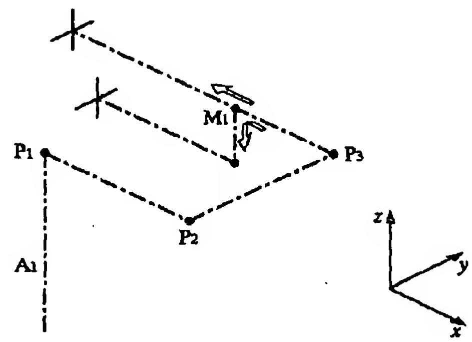
１，７，１１，１４	明るさ絞り
２，３，６，８，１５	正レンズ
４，９，１６	負レンズ
５，１０，１２ｂ，１７	接合レンズ
１２	第１レンズ群
１２ａ	両凸レンズ
１３	第２レンズ群
２１	撮影装置
２２	顕微鏡
２３，３８ｌ，３８ｒ，k_{11}，k_{21}	結像レンズ
２４，P_{11}，P_{12}，P_{13}，P_{14}，P_{15}，P_{21}，P_{22}，P_{23}，P_{24}，P_{25}，P_{26}	プリズム
２５，M_1，m_{11}，m_{21}	光路切換え部材（ミラー）
２６，２７，s_{11}，s_{21}，t_{11}，t_{21}	リレー光学系
２８，３０，３２，３４，３５，３６	反射面
２９	対物レンズ
３１	変倍光学系
３３，３７	リレーレンズ
３９ｌ，３９ｒ	接眼レンズ

A_1	光束	P_1, P_2, P_3, P_4, P_5	反射部材
h_{11}, h_{21}	瞳リレーレンズ		

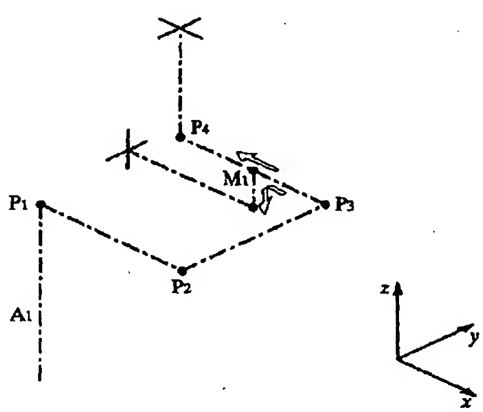
【図1】



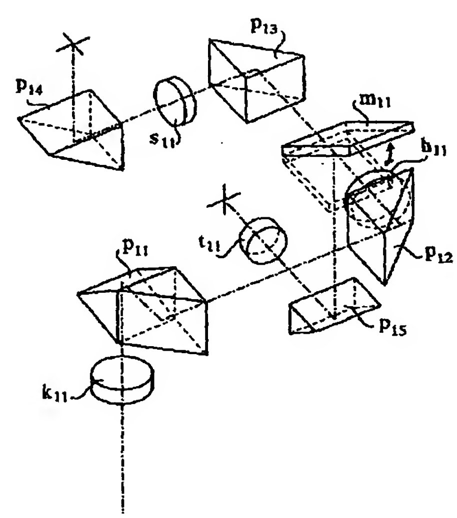
【図2】



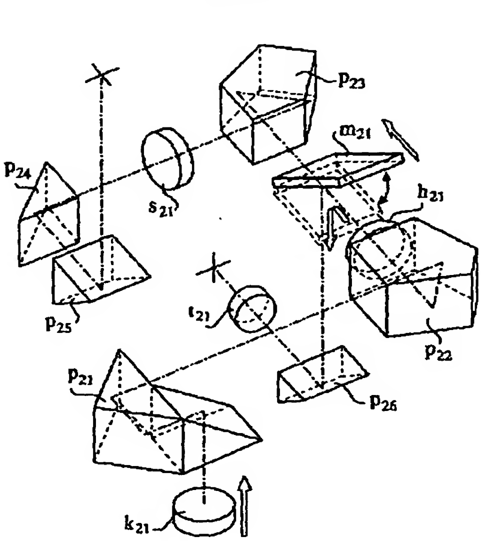
【図3】



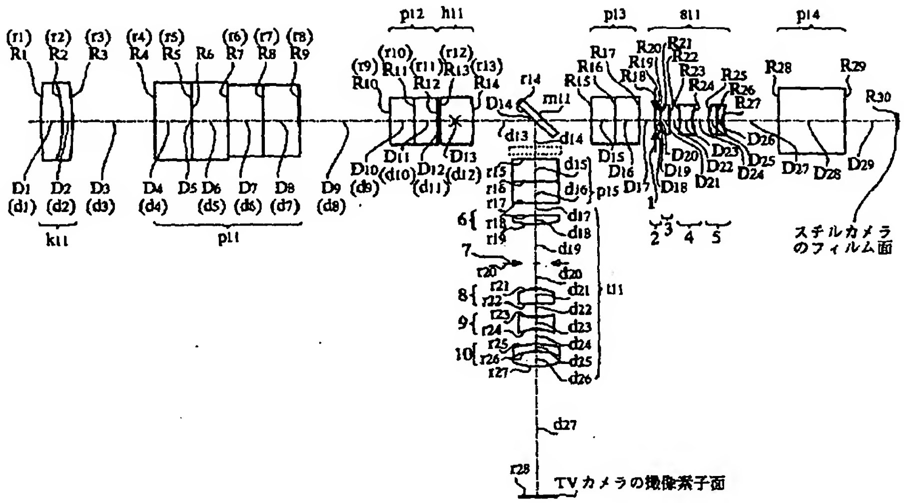
【図4】



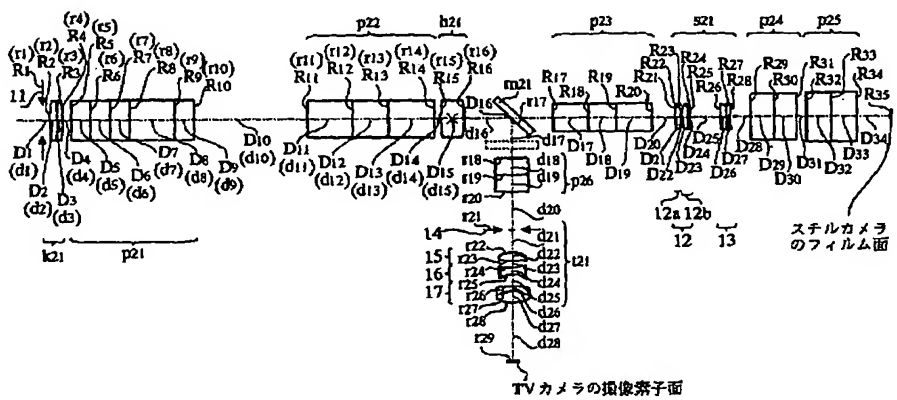
【図6】



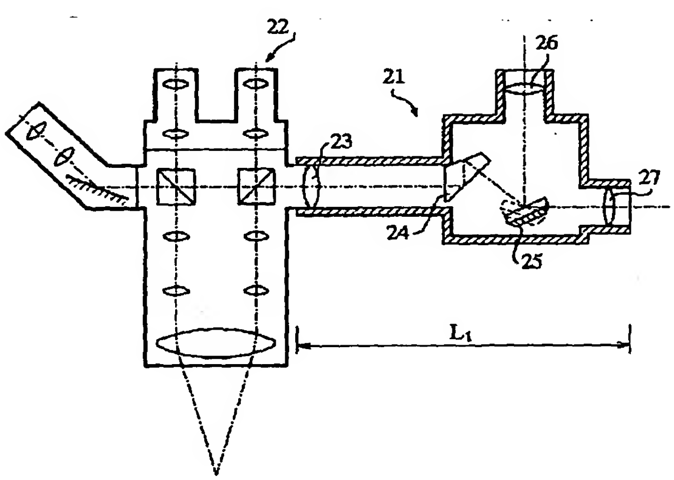
【図5】


p12 h11
p13
s11
p14
m11
p15
t11
k11
p11
TVカメラの撮像素子面
スチルカメラのフィルム面

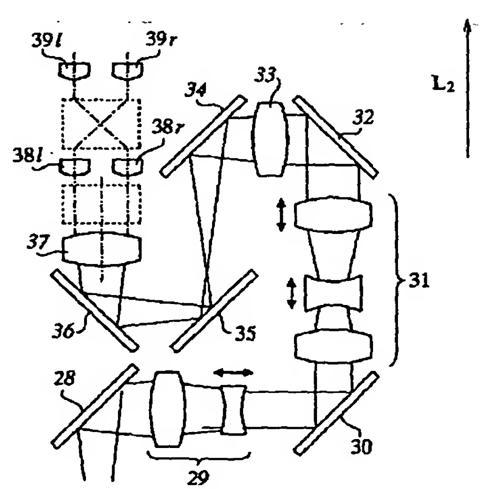
【図7】


p22 h21
p23
s21
p24 p25
m21
p26
t21
k21
p21
12a 12b
12
13
TVカメラの撮像素子面
スチルカメラのフィルム面

【図8】


22
21
26
23
27
24
25
L1

【図9】


39l
39r
34
33
32
L2
38l
38r
37
31
36
35
28
29
30

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PHOTOGRAPHIC OPTICAL SYSTEM FOR A STEREOSCOPIC MICROSCOPE

(57) Abstract
Problem to be solved: To provide a compact photographic optical system for a stereoscopic microscope that prevents unnatural extension regardless of providing a photographic optical system for use in a still camera having a long composite focal length.

Resolution Means: In the photographic optical system of the present invention, first, a luminous flux A1 is guided from the observation optical system of the stereoscopic microscope is reflected by a 1st reflection member P1 in an orthogonal direction to the luminous flux A1. Thereafter, it is reflected in turn by a 2nd reflecting member P2 in the y direction, and then by a 3rd reflection member P3 in the -x direction, and then by a 4th reflecting member P4 in the -y direction and finally by a 5th reflecting member P5 in the z direction. All of the reflecting members P1, P2,

P3, P4, and P5 are arranged on an xy plane making an incident optical axis (z axis) as a normal line.

Specification
Scope of Claims

Claim 1
A photographic optical system for a stereoscopic microscope, wherein a photographic optical system comprises reflecting members for refracting the incident optical axis within a plane of ±20° as a standard plane taking the incident optical axis for said photographic optical system as a normal line.

Claim 2
A photographic optical system for a stereoscopic microscope, comprises arrangement on the optical path that has been branched by an optical path splitter from the optical path of the observation optical system of the stereoscopic microscope, and provides optical path switching members, an optical system for use in a still camera as well as an optical system for use in a television camera, and which has the ability to guide an optical path from said observation optical system switching to said still camera optical system or television camera optical system by way of said optical path switching members; a photographic optical system, comprising at least one optical path of said still camera optical system or television camera optical system has at least 3 reflecting members within a plane of ±20° as a standard plane taking the incident optical axis for said photographic optical system as a normal line, and said optical path switching members are arranged within said plane.

Claim 3
A photographic optical system for a stereoscopic microscope, comprises arrangement on the optical path that has been branched by an optical path splitter from the optical path of the observation optical system of the stereoscopic microscope; a photographic optical system comprising an image formation lens for forming an image of the luminous flux from said observation optical system, optical path switching member(s), a relay optical system for image formation in a still camera, and a relay optical system for image formation in a television camera, and where the image formation magnification of the relay optical system for image formation in a still camera is from 1 through 7 times.

Description of the Invention

0001
Industrial Applications

The present invention relates to a photographic optical system for photographing an image captured by a stereoscopic microscope.

0002
Prior Art

Currently, the recording of still picture images by a still camera as well as the recording of moving pictures magnified and observed by a monitor through television camera photography is being performed for the purpose of recording the observed visual field in microscope observation. Together with the progress and proliferation of micro surgical technology, there is a growing need to photograph the surgical visual field as a magnified image through a microscope by way of a television camera or a still camera in order to record important treatments or surgical training with a stereoscopic microscope and especially a surgical microscope. For this reason, an optical path splitter is installed in the observation optical path of the microscope, and the attachment of a photographic device for a television camera or a still camera on the optical path split by such a device makes this possible. Photography taken with a still camera is preferred for recording the details of medical treatment or with a television camera for recording the progression of surgery. Accordingly, a surgical microscope that has the ability to attach to both of these is preferred.

0003
The photographic device in Japanese Patent Publication No. 2596926 satisfies these types of demands. Fig. 8 is a cross-sectional drawing following the optical axis that shows the constitution of such a photographic device. Photographic device 21 is used by being arranged n the optical path that is branched from the observation optical system of the microscope 22. The photographic device 21 is constituted from an image formation lens 23 for image formation of the luminous flux from the observation optical system of the microscope 22, a prism 24 that outputs to an angle that is 135° to the incident optical axis by reflecting the incident beam 2 times, an optical path switching mirror 25, a television camera relay optical system 26, and a photo capturing relay optical system 27. The photographic device 21, while having the ability for image formation onto an imaging element surface of a television camera by guiding a luminous flux from the optical path switching mirror 25 to the television camera relay optical system 26, it also has the ability for image formation onto photo film of a camera by guiding the luminous flux from the optical path switching mirror 25 to the photo relay optical system 27.

0004
Problems overcome by the invention

However, in order to match the imaging range with the observation system when using the still camera on a stereoscopic microscope, the composite focal length of the photographic optical system must be lengthened is shape to obtain a magnified image. For instance, the objective lens and the zooming lens are used in common with the observation system and the photography system of the microscope image. When the focal length BI_f of the image formation lens of the observation system is 168 mm, the field number FN is 20, the image height h of the still camera is 21.6 mm, the composite focal length required in a photographic optical system for sue in a still camera becomes:

$$(h \times 2/FN) \times BI\_f = (21.6 \times 2/20) \times 168 = 362.88 \text{ (mm)}$$

0005

Although this is only one example, in order to match the imaging range of the photographic optical system for use in a still camera with the observation system, the composite focal length of the photographic optical system thereof would necessitate about 300 mm or greater in some cases. The total length of a photographic optical system having this type of composite focal length is very long, and accordingly, when attaching this photographic optical system to a microscope in such as state it extends in the L1 direction as shown in Fig. 8 and becomes cumbersome to use by the physician.

0006

Furthermore, with a surgical microscope, there is a preference for multiple persons to be able to observe the same microscope image simultaneously from free directions in order to enable more difficult operations. In order to comply with this demand, an observation optical system is proposed that enables observation of each image seen by the left and right eye of a physician through a single zooming optical system. This constitution is shown in Fig. 9. This type of observation optical system has a single object lens 29 for the luminous flux, a zooming optical system 31, relay lenses 33 and 37, lateral pair of image formation lenses 38l and 38r, and eyepiece lenses 30l and 39r, and the various reflection planes 28, 30, 32, 34, 35 and 36 are arranged between each of the optical members to adjust the eye point position.

0007

When attaching a photographic optical system to an observation optical system constituted in such a manner, the attachment of an optical path splitter in stead of the reflection plane 32 for branching the luminous flux from the microscope into that for use in an observation optical system and that for use in a photographic optical system can be considered. In this case, the photographic optical system extends out to the L2 direction in the Drawing. With this, the weight balance between the microscope body and the arm dangling the microscope body itself breaks down resulting in the loss of operability and compactness of the photographic optical system.

0008

Therefore, the present invention gives consideration to the aforementioned problems and has as its objective to provide a compact photographic optical system for a stereoscopic microscope that prevents unnatural extension regardless of providing a photographic optical system for use in a still camera having a long composite focal length.

0009

Problem resolution means

In order to achieve the objective given above, the present invention is a photographic optical system for a stereoscopic microscope, wherein reflecting members are arranged for refracting the incident optical axis within a plane of ±20° as a standard plane taking the incident optical axis for said photographic optical system as a normal line.

0010

Furthermore, the present invention comprises a photographic optical system of a stereoscopic microscope that is arranged on the optical path that has been branched by an optical path splitter from the optical path of the observation optical system of the stereoscopic microscope, and provides optical path switching members, an optical system for use in a still camera as well as an optical system for use in a television camera, and which has the ability to guide an optical path from said observation optical system switching to said still camera optical system or television camera optical system by way of said optical path switching members; and where at least one optical path of said still camera optical system or television camera optical system has at least 3 reflecting members within a plane of ±20° as a standard plane taking the incident optical axis for said photographic optical system as a normal line, and said optical path switching members are arranged within said plane.

0011

In addition, the present invention comprises a photographic optical system of a stereoscopic microscope that is arranged on the optical path that has been branched by an optical path splitter from the optical path of the observation optical system of the stereoscopic microscope; and wherein it provides an image formation lens for forming an image of the luminous flux from said observation optical system, optical path switching member(s), a relay optical system for image formation in a still camera, and a relay optical system for image formation in a television camera, and where the image formation magnification of the relay optical system for image formation in a still camera is from 1 through 7 times.

0012

Embodiments

Fig. 1 is a conceptual drawing showing the fundamental construction of the photographic optical system for a stereoscopic microscope of the present invention. With the photographic optical system of the present invention, first, the luminous flux A1 that was guided from the observation optical system of the stereoscopic microscope not shown in the drawing is reflected by the 1st reflecting member P1 in an orthogonal direction (x direction in the drawing) in relation to the luminous flux A1. Thereafter, it is reflected in turn by a 2nd reflecting member P2 in the y direction, and then by a 3rd reflection member P3 in the -x direction, and then by a 4th reflecting member P4 in the -y direction and finally by a 5th reflecting member P5 in the z direction. All of the reflecting members P1, P2, P3, P4, and P5 are arranged on an xy plane making an incident optical axis (z axis) as a normal line. In this manner, the extension in the z direction of the photographic optical system is controlled by forming the optical path from the 1st reflecting member P1 to the 5th reflecting member P5 onto the xy plane.

0013

Furthermore, with the photographic optical system of the present invention, the optical path switching member M1 is arranged on the xy plane between the 2nd reflecting member P2 and the 3rd reflecting member P3. In addition, switching can occur between the optical path for a still camera and the optical path for a television camera by way of this optical path switching member M1. In this manner, a compact photographic optical system can be achieved while being a

photographic optical system having photographic optical systems for a still camera and for a television camera.

0014
In addition, the incident luminous flux A1 is not limited to only the x direction with the reflecting member P1, but bending is also possible to the -x direction and the ± y directions. With the photographic optical system of the present invention, if the plane is with the xy plane or is within ±20° in relation to the xy plane then the extension to the z direction can be suppressed regardless of the construction for the incident luminous flux A1 to be reflected in any direction. Further, by the mechanical elements of the photographic optical system or by rotating the image as shown in Figs. 2 and 3, the extension in the z direction of the drawing for the photographic optical system can be controlled in the same manner as above even if omitting the reflecting members P4 and P5 or only omitting the reflecting member P5. Additionally, the location of the optical path switching member M1 can also be changed as shown in the drawing. The optical path switching member M1 is preferred to be light weight and thus a mirror is optimally suited.

0015
The photographic optical system of the present invention, in addition to the optical members given above, comprises an image formation lens for image formation of the luminous flux that is guided from the observation optical system of the stereoscopic microscope, the relay optical system for image formation to the still camera, and the relay optical system for image formation to the television camera. Especially, the image formation magnification br of the relay optical system for image formation to the still camera is set between 1 through 7 times.

0016
Here, when the image formation magnification br of the relay optical system for image formation to the still camera exceeds 7 times, the correction coefficient of the relating relay optical system gets larger thereby necessitating precise assembly of the relay optical system which deteriorates the workability of the assembly process for the entire photographic optical system. Furthermore, aberration correction becomes more difficult. On the other hand, when the image formation magnification br of the relating relay optical system falls below 1 times, the luminous flux diameter near to the intermediate image point of the photographic optical system gets large thereby interfering with the compactness of the relay optical system. Furthermore, when the correction coefficient gets small and the optical axis adjustment that occurs by moving the relay optical system thereof is performed, the adjustment amount becomes too great and interferes with the compactness. Moreover, the image formation magnification br of the relay optical system for image formation to the still camera is preferred to be set within the range of 3 to 5 times, or the setting of 3.5 times is considered optimal.

0017
With the photographic optical system of the present invention, the luminous flux diameter of subsequent intermediate image formation positions can be sufficiently reduced by arranging a different lens in the position of the intermediate image that is formed by the image formation lens for image formation of the luminous flux that is guided from the observation optical system of the stereoscopic microscope, thereby devising the compactness of the entire optical system.

Furthermore, optical performance is not deteriorated. Here, with the photographic optical system of the present invention, when the F no. of the image formation lens for image formation of the luminous flux from the observation optical system of the stereoscopic microscope is Fno_k, and the thickness of the lens arranged at the intermediate image position that is formed by the image formation lens is t, then it is preferred to satisfy the following conditional expression 1.

Conditional Expression 1 $0.3 < Fno\_k/t < 7.5$

0018
When the value of Fno_k/t exceeds the upper limit of the value range given in the conditional expression 1, the lens thickness arranged in the intermediate image position becomes thin causing the intermediate image and the lens surface to overlap where dust that adheres to the lens and scratches appear on the images of the still camera and television camera generating a problem whereby it is difficult to obtain a favorable image. Meanwhile, when the value of Fno_k/t falls below the lower limit of the value range given the conditional expression 1, then the optical performance of the photographic optical system worsens. Especially in the case when the thickness of the lens arranged in the intermediate position is thick, the intermediate image and the lens surface separate to far causing distortion to worsen which is not desirable.

0019
Furthermore, the relay optical system for image formation to a still camera comprises a 2 group construction in order from the photographic object side with a first lens group having a positive focal length and a second lens group having a negative focal length. In other words, the total length of the relay optical system can be shortened if a telephoto type construction is adopted with a convex lens in the first lens group and a concave lens in the second lens group. Furthermore, use of a cemented lens as the concave lens of the second lens group is effective in order to devise compactness of the relay optical system while correcting chromatic aberrations. In addition, it is preferred that at least cemented lens is included in each of the lens groups. By constituting in such a manner, the chromatic aberrations generated by each of the lens groups can be favorably corrected.

0020
With the photographic optical system of the present invention, the chromatic aberrations on the axis by the cemented lens of the first lens group as well as the chromatic aberration for the magnification by the second lens group can both be corrected, and favorable optical performance can be obtained while shortening the total length of the photographic optical system.

0021
The present invention will be explained in detail hereafter based on an Embodiment and depicted by Drawings.

0022
Embodiment 1

Fig. 4 is a drawing showing the construction of the photographic optical system of the

stereoscopic microscope that relates to the present Embodiment. Fig. 5 is a cross-sectional drawing following the optical axis of the photographic optical system shown in Fig. 4. The photographic optical system of the present Embodiment arranges each in order from the observation optical system side of the stereoscopic microscope not shown in the drawing: an image formation lens k11, a twice reflecting prism P11, a right angle prism p12, a lens (pupil relay lens) h11 arranged in the intermediate position obtained by the image formation lens k11, an optical path switching mirror m11, a right angle prism p13, a still camera relay optical system s11, and a right angle prism p14. Furthermore, a right angle prism p15 and a television camera relay optical system t11 are arranged in that order on the optical axis that is branched by the optical path switching mirror m11.

0023
Here, the still camera relay optical system s11 is constructed to arrange in order from the right angle prism p13 side a brightness diaphragm 1, a positive lens 2, a positive lens 3, a negative lens 4, a cemented lens 5 comprised of a positive lens and a negative lens. On the other hand, the television camera relay optical system t11 is constructed to arrange in order from the right angle prism p15 side a positive lens 6, a brightness diaphragm 7, a positive lens 8, a negative lens 9, a cemented lens 10 comprised of a negative lens and a positive lens.

0024
The photographic optical system of the present Embodiment, first, forms the intermediate image by passing the luminous flux, which is guided from the observation optical system, through the image formation lens k11, then it is reflected by the twice reflecting prism p11 orthogonally in the direction following the plane that makes the incident optical axis a normal line. Next, that image is reflected at the right angle prism p12, and after narrowing the luminous flux diameter thereafter at the pupil relay lens h11, as will be described below, it is guided to the still camera relay optical system s11 or the television camera relay optical system t11.

0025
At the time of photo capturing, the optical path switching mirror m11 is moved to the dotted line position in the drawing. By so doing, the microscope image that passed through the pupil relay lens h11 is transmitted in turn through the right angle prism p13, and the still camera relay optical system s11 then it is guided to the still camera (not shown) by the right angle prism p14. Meanwhile, at the time of television filming, the optical path switching mirror m11 moves to the solid line position in the drawing. The microscope image that passed through the pupil relay lens h11 is reflected by the optical path switching mirror m11 and guided to the right angle prism p15. In addition, the image that is reflected by the right angle prism p15 is guided to the television camera (not shown) through the television camera relay optical system t11.

0026
In this manner, with the present Embodiment, the focal length of the photographic optical system becomes long, but it is possible to prevent the extension in the direction along the incident optical axis of the photographic optical system and achieve a compact photographic optical system by forming the optical path in the direction along the plane that makes the incident optical axis to the photographic optical system a normal line.

0027
Furthermore, with the present Embodiment, by setting the magnification br of the still camera relay optical system s11 to 4.8 times, the correction coefficient gets smaller thereby making it possible to favorably correct the aberrations.

0028
In addition, with the photographic optical system of the present Embodiment, when the F no. of the image formation lens k11 for image formation of the luminous flux from the observation optical system of the stereoscopic microscope is Fno _k/t, and the thickness of the pupil relay lens h11 arranged at the intermediate position that is obtained by the image formation lens k11 is t, then Fno _k/t = 0.86. In this manner, aberrations can be favorably corrected without dust adhered to the pupil relay lens h11 and scratches appearing on the images of the still camera and television camera.

0029
The numerical values of each optical member constructing the photographic optical system of the present Embodiment will be given hereafter as data.

0030
At the time of still camera photography.

R1 = 74.8010		
D1 = 5.8000	n1 = 1.72916	n1 = 54.68
R2 = -37.9660		
D2 = 2.5000	n2 = 1.80100	n2 = 34.97
R3 = -202.1440		
D3 = 21.7000		
R4 = ¥		
D4 = 10.0000	n4 = 1.56883	n4 = 56.33
R5 = ¥		
D5 = 10.0000	n5 = 1.56883	n5 = 56.33

0031

R6 = ¥		
D6 = 0		
R7 = ¥		
D7 = 9.5000	n7 = 1.56883	n7 = 56.33
R8 = ¥		
D8 = 9.5000	n8 = 1.56883	n8 = 56.33
R9 = ¥		
D9 = 24.0000		
R10 = ¥		
D10 = 6.0000	n10 = 1.56883	n10 = 56.33

0032

R11 = ¥
D11 = 6.0000 n11 = 1.56883 n11 = 56.33
R12 = ¥
D12 = 0.5000
R13 = ¥
D13 = 9.0000 n13 = 1.51633 n13 = 64.15
R14 = -80.0080
D14 = 31.5000
R15 = ¥
D15 = 6.0000 n15 = 1.56883 n15 = 56.33

0033
R16 = ¥
D16 = 6.0000 n16 = 1.56883 n16 = 56.33
R17 = ¥
D17 = 4.6590
R18 = ¥
D18 = 0
R19 = 34.7920
D19 = 1.6700 n19 = 1.51633 n19 = 64.15
R20 = -22.7570
D20 = 0.1000

0034
R21 = 8.0580
D21 = 2.4000 n21 = 1.51633 n21 = 64.15
R22 = ¥
D22 = 2.6500
R23 = -20.6720
D23 = 3.1800 n23 = 1.76182 n23 = 26.52
R24 = 7.3790
D24 = 4.3700
R25 = 15.3450
D25 = 2.0000 n25 = 1.72151 n25 = 29.24

0035
R26 = -29.1410
D26 = 1.9300 n26 = 1.58913 n26 = 61.18
R27 = 12.9180
D27 = 14.5260
R28 = ¥
D28 = 17.0000 n28 = 1.74330 n28 = 49.22
R29 = ¥
D29 = 89.7579
R30 = ¥

0036

At the time of television filming.

r1 = 74.8010
d1 = 5.8000 n1 = 1.72916 n1 = 54.68
r2 = -37.9660
d2 = 2.5000 n2 = 1.80100 n2 = 34.97
r3 = -202.1440
d3 = 21.7000
r4 = ¥
d4 = 1.0000 n4 = 1.56883 n4 = 56.33
r5 = ¥
d5 = 1.0000 n5 = 1.56883 n5 = 56.33

0037

r6 = ¥
d6 = 9.5000 n6 = 1.56883 n6 = 56.33
r7 = ¥
d7 = 9.5000 n7 = 1.56883 n7 = 56.33
r8 = ¥
d8 = 24.0000
r9 = ¥
d9 = 6.0000 n9 = 1.56883 n9 = 56.33
r10 = ¥
d10 = 6.0000 n10 = 1.56883 n10 = 56.33

0038

r11 = ¥
d11 = 0.5000
r12 = 80.0080
d12 = 9.0000 n12 = 1.51633 n12 = 64.15
r13 = -80.0080
d13 = 16.5000
r14 = ¥
d14 = 10.2000
r15 = ¥
d15 = 6.0000 n15 = 1.56883 n15 = 56.33

0039

r16 = ¥
d16 = 6.0000 n16 = 1.56883 n16 = 56.33
r17 = ¥
d17 = 3.0000
r18 = ¥
d18 = 2.2000 n18 = 1.51633 n18 = 64.15
r19 = -38.2470

d19 = 10.5000
r20 = ¥
d20 = 6.6800

0040
r21 = 10.2370
d21 = 4.0000 n21 = 1.69680 n21 = 55.53
r22 = 82.7710
d22 = 3.4100
r23 = -17.8940
d23 = 3.3000 n23 = 1.74077 n23 = 27.79
r24 = 8.1750
d24 = 4.2900
r25 = 34.6150
d25 = 1.5000 n25 = 1.64769 n25 = 33.80

0041
r26 = 13.4990
d26 = 4.0000 n26 = 1.78590 n26 = 44.19
r27 = -18.4600
d27 = 34.4310
r28 = ¥

0042
Embodiment 2
Fig. 6 is a drawing that shows the construction of the photographic optical system of the stereoscopic microscope that relates to the present Embodiment. Further, Fig. 7 is a cross-sectional drawing along the optical axis of the photographic optical system shown in Fig. 6. The photographic optical system of the present Embodiment arranges each in order from the observation optical system side of the stereoscopic microscope not shown in the drawing: a brightness diaphragm 11, an image formation lens k21, a three-time reflecting prism P21, a penta prism p22, a lens (pupil relay lens) h21 arranged in the intermediate position obtained by the image formation lens k21, an optical path switching mirror m21, a penta prism p23, a still camera relay optical system s21, and right angle prisms p24 and p25. Furthermore, a right angle prism p26 and a television camera relay optical system t21 are arranged in that order on the optical axis that is branched by the optical path switching mirror m21.

0043
Here, the still camera relay optical system s21 is constructed to arrange in order from the penta prism p23 side a first lens group 12 providing a positive refractive power and a second lens group providing negative refracting power. In addition, the first lens group is constructed by arranging in order from the penta prism p23 side a bi-convex lens 12a and a positive cemented lens 12b comprised of a positive lens and a negative lens. While the second lens group 13 is constructed of a negative cemented lens comprised of a positive lens and a negative lens. On the other hand, the television camera relay optical system t21 is constructed to arrange in order from the penta

prism p26 side a brightness diaphragm 14, a positive lens 15, a negative lens 16, a cemented lens 17 comprised of a negative lens and a positive lens.

0044
The photographic optical system of the present Embodiment, first, forms the intermediate image by passing the luminous flux, which is guided from the observation optical system, through the image formation lens k21, then it is reflected by the three-time reflecting prism p21 orthogonally in the direction following the plane that makes the incident optical axis a normal line. Next, that image is reflected at the penta prism p22, and after narrowing the luminous flux diameter thereafter at the pupil relay lens h21, as will be described below, the luminous flux is guided to the still camera relay optical system s21 or the television camera relay optical system t21.

0045
At the time of photo capturing, the optical path switching mirror m21 is moved to the dotted line position in the drawing. By so doing, the microscope image that passed through the pupil relay lens h21 is transmitted in turn through the penta prism p23 and the still camera relay optical system s21 then it is guided to the still camera (not shown) through the right angle prisms p24 and p25. Meanwhile, at the time of television filming, the optical path switching mirror m21 moves to the solid line position in the drawing. The microscope image that passed through the pupil relay lens h21 is reflected by the optical path switching mirror m21 and guided to the right angle prism p26. In addition, the image that is reflected by the right angle prism p26 is guided to the television camera (not shown) through the television camera relay optical system t21.

0046
In this manner, with the present Embodiment and in the same manner as with Embodiment 1, the focal length of the photographic optical system becomes long, but it is possible to prevent the extension in the direction along the incident optical axis of the photographic optical system and achieve a compact photographic optical system by forming the optical path in the direction along the plane that makes the incident optical axis to the photographic optical system a normal line.

0047
Furthermore, with the present Embodiment, by setting the magnification br of the still camera relay optical system s21 to 3.7 times, the correction coefficient gets smaller than the photographic optical system of Embodiment 1 thereby making it possible to favorably correct the aberrations.

0048
In addition, with the photographic optical system of the present Embodiment, when the F no. of the image formation lens k21 for image formation of the luminous flux from the observation optical system of the stereoscopic microscope is Fno _k/t, and the thickness of the pupil relay lens h21 arranged at the intermediate position that is obtained by the image formation lens k21 is t, then Fno _k/t = 0.86. In this manner, aberrations can be favorably corrected without dust adhered to the pupil relay lens h21 and scratches appearing on the images of the still camera and television camera.

0049
The numerical values of each optical member constructing the photographic optical system of the present Embodiment will be given hereafter as data.

0050
At the time of still camera photography.

R1 = ¥
D1 = 3.0500
R2 = 62.3180
D2 = 3.0000   n2 = 1.48749   n2 = 70.23
R3 = -53.3190
D3 = 1.8000   n3 = 1.72342   n3 = 37.95
R4 = -137.0720
D4 = 3.0000
R5 = ¥
D5 = 8.0000   n5 = 1.56883   n5 = 56.33

0051
R6 = ¥
D6 = 8.0000   n6 = 1.56883   n6 = 56.33
R7 = ¥
D7 = 8.0000   n7 = 1.56883   n7 = 56.33
R8 = ¥
D8 = 8.0000   n8 = 1.56883   n8 = 56.33
R9 = ¥
D9 = 8.0000   n9 = 1.56883   n9 = 56.33
R10 = ¥
D10 = 44.0000

0052
R11 = ¥
D11 = 16.9000   n11 = 1.51633   n11 = 64.15
R12 = ¥
D12 = 14.0000   n12 = 1.51633   n12 = 64.15
R13 = ¥
D13 = 16.9000   n13 = 1.51633   n13 = 64.15
R14 = ¥
D14= 2.0000
R15 = 46.0390
D15 = 9.0000   n15 = 1.51633   n15 = 64.15

0053
R16 = -46.0390
D16 = 34.3000

R17 = ¥
D17 = 13.2800 n17 = 1.51633 n17 = 64.15
R18 = ¥
D18 = 11.0000 n18 = 1.51633 n18 = 64.15
R19 = ¥
D19 = 13.2800 n19 = 1.51633 n19 = 64.15
R20 = ¥
D20 = 9.0100

0054
R21 = ¥
D21 = 2.0000 n21 = 1.51633 n21 = 64.14
R22 = -36.5760
D22 = 0.2000
R23 = 16.9530
D23 = 2.4000 n23 = 1.51633 n23 = 64.14
R24 = -30.2290
D24 = 1.1000 n24 = 1.76182 n24 = 26.52
R25 = ¥
D25 = 11.9000

0055
R26 = -58.4740
D26 = 2.0000 n26 = 1.78472 n26 = 25.68
R27 = -19.8070
D27 = 1.1000 n27 = 1.72916 n27 = 54.68
R28 = 10.4010
D28 = 8.1900
R29 = ¥
D29 = 8.5000 n29 = 1.73400 n29 = 51.47
R30 = ¥
D30 = 8.5000 n30 = 1.73400 n30 = 51.47

0056
R31 = ¥
D31 = 4.0000
R32 = ¥
D32 = 9.5000 n32 = 1.73400 n32 = 51.47
R33 = ¥
D33 = 9.5000 n33 = 1.73400 n33 = 51.47
R34 = ¥
D34 = 75.4978
R35 = ¥

0057

At the time of television filming.

r1 = ¥		
d1 = 3.0500		
r2 = 62.3180		
d2 = 3.0000	n2 = 1.48749	n2 = 70.23
r3 = -53.3190		
d3 = 1.8000	n3 = 1.72342	n3 = 37.95
r4 = -137.0720		
d4 = 3.0000		
r5 = ¥		
d5 = 8.0000	n5 = 1.56883	n5 = 56.33

0058

r6 = ¥		
d6 = 8.0000	n6 = 1.56883	n6 = 56.33
r7 = ¥		
d7 = 8.0000	n7 = 1.56883	n7 = 56.33
r8 = ¥		
d8 = 16.0000	n8 = 1.56883	n8 = 56.33
r9 = ¥		
d9 = 8.0000	n9 = 1.56883	n9 = 56.33
r10 = ¥		
d10 = 44.0000		

0059

r11 = ¥		
d11 = 16.9000	n11 = 1.51633	n11 = 64.15
r12 = ¥		
d12 = 14.0000	n12 = 1.51633	n12 = 64.15
r13 = ¥		
d13 = 16.9000	n13 = 1.51633	n13 = 64.15
r14 = ¥		
d14 = 2.0000		
r15 = 46.0390		
d15 = 9.0000	n15 = 1.51633	n15 = 64.15

0060

r16 = -46.0390		
d16 = 16.5000		
r17 = ¥		
d17 = 15.0000		
r18 = 46.0390		
d18 = 6.0000	n18 = 1.56883	n18 = 56.36
r19 = ¥		

d19 = 6.0000 n19 = 1.56883 n19 = 56.36
r20 = ¥
d20 = 15.2000

0061
r21 = ¥
d21 = 8.0000
r22 = 7.9020
d22 = 2.8500 n22 = 1.80610 n22 = 40.92
r23 = 52.0250
d23 = 2.8000
r24 = -15.0020
d24 = 2.5000 n24 = 1.80518 n24 = 25.42
r25 = 5.6570
d25 = 4.7000

0062
r26 = 26.0680
d26 = 1.3000 n26 = 1.78472 n26 = 25.68
r27 = 10.2000
d27 = 4.6000 n27 = 1.78590 n27 = 44.20
r28 = -13.2510
d28 = 30.8540
r29 = ¥

0063
Further, R1, r1,... in the numerical data of each Embodiment given above refers to the curvature radius of the lens planes; D1, d1,... refers to thickness of each lens or to the variable spacing thereof; n1, n2,... refers to the refractive index of each lens; and n1, n2,... refers to the Abbe constant of each lens.

0064
Here, with the photographic optical system shown by each Embodiment 1 and Embodiment 2, a twice reflecting prism, a three time reflecting prism and a penta prism are used; however, a right angle prism may also be substituted for each prism if rotation of the image is possible with the still camera or television camera. Furthermore, use of a mirror in stead of the prism is also possible. It goes with out saying that the position of the still camera or television camera may also be interchanged.

0065
As given in the description above, the photographic optical system of the stereoscopic microscope according to the present invention provides the composition described in the Scope of Claims as well as the composition given below in items (1) through (3).

0066

(1) A photographic optical system for a stereoscopic microscope according to Claim 3, wherein a lens arranged in the intermediate image position that is formed by the image formation lens for image formation of a luminous flux from an observation optical system of said stereoscopic microscope.

0067

(2) A photographic optical system for a stereoscopic microscope according to Claim 1, wherein when an F no. of the image formation lens for image formation of a luminous flux from an observation optical system of said stereoscopic microscope is Fno _k, and the thickness of the lens arranged at said intermediate image position is t, and the conditional expression below is satisfied.

$$0.3 < Fno\_k/t < 7.5$$

0068

(3) A photographic optical system for a stereoscopic microscope according to Claim 2, wherein a relay optical system for image formation to a still camera has a two group construction arranging in order from the observation optical system side of said stereoscopic microscope a first lens group providing a positive focal length and a second lens group providing a negative focal length, andat least one cemented lens is included in each lens group.

0069

Efficacy of the Invention

According to the present invention as given above, a compact photographic optical system for a stereoscopic microscope can be provided without unnatural extension of the photographic optical system even if the focal length of the photographic optical system is long.

Brief Description of Drawings

Fig. 1 is a conceptual drawing showing the construction of the photographic optical system of the stereoscopic microscope that relates to the present invention.

Fig. 2 is a conceptual drawing showing another construction of the photographic optical system of the stereoscopic microscope that relates to the present invention.

Fig. 3 is a conceptual drawing showing another construction of the photographic optical system of the stereoscopic microscope that relates to the present invention.

Fig. 4 is a drawing showing the construction of the photographic optical system of the stereoscopic microscope that relates to Embodiment 1.

Fig. 5 is a cross-sectional drawing along the optical axis of the photographic optical system shown in Fig. 4

Fig. 6 is a drawing showing the construction of the photographic optical system of the

stereoscopic microscope that relates to Embodiment 2.

Fig. 7 is a cross-sectional drawing along the optical axis of the photographic optical system shown in Fig. 6.

Fig. 8 is a cross-sectional drawing along the optical axis showing the construction of a photographic optical system of a microscope of the prior art.

Fig. 9 is a cross-sectional drawing along the optical axis showing the construction of a photographic optical system of a microscope of the prior art.

Explanation of the Reference Numerals

1, 7, 11, 14	Brightness diaphragm
2, 3, 6, 8, 15	Positive lens
4, 9, 16	Negative lens
5, 10, 12b, 17	Cemented lens
12	First lens group
12a	Bi-convex lens
13	Second lens group
21	Photographic device
22	Microscope
23, 38l, 38r, k11, k21	Image formation lens
24, P11, P12, P13, P14, P15, P21, P22, P23, P24, P25, P26	Prism
25, M1, m11, m21	Optical path switching member (mirror)
26, 27, s11, s21, t11, t21	Relay optical system
28, 30, 32, 34, 35, 36	Reflecting surface
29	Objective lens
31	Zooming optical system
33, 37	Relay lens
39l, 39r	Eyepiece lens

Explanation of the Drawings

A1	Luminous flux
H11, h21	Pupil relay lens
P1, P2, P3, P4, P5,	Reflecting member